

General environmental conditions for high power semiconductors



This application note on environmental conditions (the “Note”) describes the environmental conditions for storage; transportation and handling; and operation of our high power semiconductors.

¹ BPM: BiPolar power module

² HLWD: Housing less welding diode

³ The gate unit of the IGCT is not hermetic. The press-pack thyristor of the IGCT is hermetic

⁴ Includes rectifier diodes, avalanche diodes, fast recovery diodes and other types

⁵ WD: Welding diode

⁶ Thyristor includes BCT

1. Scope

Semiconductors housed in plastic packaging are non-hermetic. This means the housings can be permeated by humidity and gases in both directions (e.g. through openings at the power terminals). Once water molecules are inside the housing, they can reduce the blocking voltage or initiate corro-

sion. Condensation must be avoided. Due to the importance of climatic conditions, these parameters are highlighted separately in this document.

2. Products

The Note applies to the following products and conditions:

Environment	Non-hermetic products	Hermetic products
Storage, transportation and handling	62Pak, LoPak1, HiPak, LinPak, StakPak, BPM ¹ , HLWD ² , IGCT ³	Press-pack diode ⁴ , WD ⁵ , thyristor ⁶ and GTO
Industrial operation - stationary use		
Traction operation - ground vehicle installations	HiPak, LinPak	Press-pack diode, thyristor and GTO

Table of contents

01	Scope
01	Products
03	Storage
03	Transportation and handling
03	Operation
03	General operation
04	Industrial operation - Stationary use at weather protected locations
05	Traction operation - Ground vehicle installations
06	References
06	Revision history
06	Important information and warnings

⁷ IGBT are used in 62Pak, LoPak1, HiPak, LinPak and StakPak

⁸ In deviation to IEC 60721-3-5 reference to ISO 9223. Condensation, salt mist, road salt and splashing water are not allowed

⁹ In deviation to class 1K21

¹⁰ In deviation to IEC 60721-3-5 reference to ISO 9223. Condensation, salt mist, road salt and splashing water are not allowed.

¹¹ In deviation to class 2K11

3. ESD

IGBTs⁷ and IGCTs are electrostatic sensitive devices. Uncontrolled discharge e.g. voltage from a human body may destroy the device. IGBT gate-emitter terminals are electrostatic sensitive contacts and must be short-circuited during storage, transportation and handling. For IGCTs, the printed circuit board of the gate unit is electrostatic sensitive and should not be touched. When these devices are within an assembly (e.g. modules connected with gate units), a separate assessment is required. Further information is provided in the IEC 61340-5-1 standard "Protection of electronic devices from electrostatic phenomena".

4. Storage

IEC 60721-3-1 classifies the groups of environmental parameters and their severities to which products together with their original packaging are subjected when stored. After packaging, the product can generally be stored indoors in the original package for the following times:

Products	Storage time
62Pak, LoPak1, BPM, HLWD	2 years
HiPak, LinPak, StakPak, standard welding diode, IGCT	5 years
Press-pack diode, thyristor and GTO	20 years

An overview of the environmental conditions according to IEC 60721-3-1 is given in the following table.

Environmental condition	Class
Climatic conditions	1K21
Special climatic conditions	1Z1
Biological conditions	1B1
Chemically active substances	ISO 9223 category C2 ⁸
Mechanically active substances	1S10
Mechanical	1M10
Climatic conditions	
Temperature	5 °C ... 40 °C
Relative humidity	20 % ... 75 % ⁹
Condensation, precipitation, ice, frost and similar	Not allowed at any time

5. Transportation and handling

IEC 60721-3-2 classifies the groups of environmental parameters and their severities to which a product is subjected while being transported and handled. When transporting in the original packaging, a maximum duration of 30 days should not be exceeded. An overview of the environmental conditions defined in IEC 60721-3-2 is given in the following tables.

Environmental condition	Class
Climatic conditions	2K11
Biological conditions	2B1
Chemically active substances	ISO 9223 category C3 ¹⁰
Mechanically active substances	2S1
Mechanical conditions	2M4
Climatic conditions	
Temperature	-25 °C ... 60 °C ¹¹
Relative humidity	5 % ... 85 %
Condensation, precipitation, ice, frost and similar	Not allowed at any time

6. Operation

6.1. General operation

Assumed operational life

The operational lifetime of products is determined primarily by the applied functional load (see, for example, the application notes on load-cycling capability and mounting instructions). Nevertheless, environmental conditions may also affect the assumed operational lifetime. Provided the requirements and conditions described in this application note and other relevant application notes and documentation are met, we expect (but do not guarantee) an assumed operational lifetime as listed in the table below:

Product	Assumed operational lifetime
62Pak, LoPak, HLWD, WD, BPM	5 - 10 years
HiPak, LinPak, StakPak, GTO, IGCT	20 - 30 years
Press-pack diode and thyristor	25 - 35 years

Altitude

For installation at higher altitudes it is necessary to consider the reduction of the dielectric strength and cooling effect of the air. For further information see IEC 60664-1 and EN 50124-1.

¹² The Comparative Tracking Index or CTI is used to measure the electrical breakdown (tracking) properties of an insulating material.

¹³ No CTI for WD

¹⁴ Condensation, salt mist, road salt and splashing water are not allowed.

¹⁵ No electrically conductive material allowed.

¹⁶ The mechanical robustness against shock and vibration strongly depends on the mechanical mounting. For proper mounting see applicable application notes. 3M12 was tested between 5 Hz and 150 Hz, while the acceleration spectral density (other common abbreviations are APSD, PSD or ASD) between 85 Hz and 150 Hz was tested with a minimum PSD level of $0.034 \text{ (m/s}^2\text{)}^2\text{/Hz}$. The IGCT was tested with sinusoidal vibration in deviation to IEC 60721-3-3, which uses random vibration. It is recommended devices are tested in the customer specific converter construction.

¹⁷ In deviation to class 3K22. The applicable temperature range for IGCTs is specified in the data sheet.

¹⁸ In deviation to class 3K24

Cosmic ray

Our high power semiconductors are designed to reduce the failure rate caused by cosmic rays. Cosmic ray induced failures, however, can impact every power electronic circuit. In particular, a careful assessment is required when using semiconductors in applications with a high utilization of the device's blocking capability and for equipment operated at high altitudes. For more information and guidance see the relevant application notes.

Pollution degree

Creepage and clearance distances for the housing material are specified in the product data sheet. The Comparative Tracking Index (CTI¹²) is more than 600 for press-pack diodes, thyristors, GTOs and the

gate-anode isolation of the IGCT. Other products have their CTI specified in the data sheet¹³. The applicable pollution degree rating depends on the application and voltage load. For further information, see the relevant product data sheet, IEC 60664-1 and EN 50124-1.

6.2. Industrial operation - Stationary use at weather protected locations

IEC 60721-3-3 classifies groups of environmental parameters and their severities to which products are subjected when installed for stationary use at weather protected locations. The following tables provide an overview of the environmental conditions according to IEC 60721-3-3.

Environmental condition	Non-hermetic products	Hermetic products
Climatic	3K22	3K24
Special climatic	3Z3	3Z3
Biological	3B1	3B1
Chemically active substances ¹⁴	ISO 9223 category C3	ISO 9223 category C5
Mechanically active substances ¹⁵	3S5	3S6
Mechanical ¹⁶	3M12	3M12

Climatic conditions	Class 3K22	Class 3K24
Air temperature	-25°C ... 55°C ¹⁷	-25°C ... 55°C
Relative humidity	5 % ... 85 %	5 % ... 95 % ¹⁸
Absolute humidity	0.5 g/m ³ ... 25 g/m ³	0.5 g/m ³ ... 29 g/m ³
Rate of change of temperature	0.5 °C/min	0.5 °C/min
Low air pressure	70 kPa	70 kPa
Movement of surrounding air	1 m/s	5 m/s
Condensation	No	No
Water from sources other than rain	No	No
Formation of ice and frost (including freeze-thaw)	No	No

¹⁹ In deviation to IEC 60721-3-5 reference to ISO 9223. Condensation, salt mist, road salt and splashing water are not allowed.

²⁰ No electrically conductive material allowed.

²¹ In deviation to IEC 60721-3-5

²² In deviation to class 5K3

²³ The operation at low air pressure due to high altitude is limited by the influence of cosmic rays. During operation at low air pressure sufficient air-cooling must be guaranteed.

²⁴ In deviation to class 5K3

6.3. Traction operation - Ground vehicle installations

IEC 60721-3-5 and IEC 61373 classify the environmental conditions of operation for ground vehicle installations. IEC 60721-3-5 classifies the environmental parameters and their severities to which a product will be exposed, while mechanical condi-

tions are classified according to IEC 61373. An overview of the environmental conditions specified in IEC 60721-3-5 is given in the following tables.

Environmental condition	Class
Climatic	5K3
Biological	5B1
Chemically active substances	ISO 9223 category C3 ¹⁹
Mechanically active substances ²⁰	5S2
Contaminating fluids	5F1
Mechanical	IEC 61373 Cat. 1 Class B ²¹
Climatic conditions	5K3
Low air temperature	-40 °C
High air temperature in ventilated compartments (except engine compartments) or outdoor air	+40 °C
High air temperature in unventilated compartments (except engine compartments)	+70 °C
Change of temperature air/air	-40 °C /+30 °C
Gradual change of temperature air/air, except in engine compartments	-40 °C /+30 °C 5 °C/min
Change of temperature air/water, except in engine compartments	No ²²
Relative humidity, not combined with rapid temperature changes, except in engine compartments of vehicles powered by internal combustion engines	95 % RH / +45 °C
Relative humidity, combined with rapid temperature changes, air/air, at high relative humidities. Not in close proximity of refrigerator air conditioning systems	95 % RH -40 °C / +30 °C
Absolute humidity combined with rapid temperature changes, air/air at high water content	60 g/m ³ of air +70 °C / +15 °C
Low relative humidity	10 % RH / +30 °C
Low air pressure	70 kPa ²³
Movement of surrounding medium, air	20 m/s
Precipitation, rain	
Water from sources other than rain	No ²⁴
Wetness	

7. References

IEC 60721-3-1:2018 Environmental Classifications – Storage
 IEC 60721-3-2:2018 Environmental Classifications – Transportation and handling
 IEC 60721-3-3:2019 Environmental Classifications – Stationary use at weather protected locations
 IEC 60721-3-5:1997 Environmental Classifications – Ground vehicle installations
 IEC 61340-5-1:2016 Protection of electronic devices from electrostatic phenomena
 IEC 61373:2010 Railway applications - Shock and vibration tests
 IEC 60664-1:2007 Insulation coordination for equipment within low-voltage systems
 EN 50124-1:2017 Railway applications - Insulation coordination - clearances and creepage distances
 ISO 9223:2012 Corrosion of metals and alloys – Corrosivity of atmospheres
 5SYA2042 Application note - IGBT Cosmic Ray Capability
 5SYA2046 Cosmic rays on IGCT
 5SYA2061 Failure rates of FRD due to cosmic rays
 5SYA2043 Load-cycling capability of HiPak
 Several mounting instructions available on our webpage

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8. Revision history

Version	Change	Authors
01	2020-01-22	Thomas Gloor

Important information and warnings

This document is for information purposes only. Nothing in this document can be construed or be considered as guarantee or assurance of product characteristics. This document generally describes certain characteristics of products in typical appli-

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